# Classroom Processes and their Relationship to Achievement in Mathematics

**1985 Mathematics Assessment**

· MINISTRY OF EDUCATION ·

Province of British Columbia

STUDENT ASSESSMENT

# CLASSROOM PROCESSES AND THEIR RELATIONSHIP TO ACHIEVEMENT IN MATHEMATICS

## An Analysis of Factors Related to Students' Opinions about and Achievement in Mathematics

by

Alan R. Taylor
School District 43 (Coquitlam)

David F. Robitaille
University of British Columbia

Student Assessment Branch
Ministry of Education
Province of British Columbia

December, 1987

89-05851/

**Canadian Cataloguing in Publication Data**

Taylor, Alan Richard, 1940-

Classroom processes and their relationship to achievement in mathematics

Bibliography: p.
ISBN 0-7718-8763-9

1. Mathematical ability. 2. Mathematics - Study and teaching - British Columbia. I. Robitaille, David F. II. British Columbia. Student Assessment Branch. III. Title.

QA14.C32B756 1989 510'.7'0711 C89-092097-4

## EXECUTIVE SUMMARY

Data for the 1985 Mathematics Assessment for Grades 4, 7, and 10 were used to investigate relationships between student achievement and attitude, and between these student outcomes and various teacher variables. The relationships that were identified are summarized below. The relationships tended to be stronger at the grade 10 level than at grades 4 and 7.

1. Student Achievement and Student Opinion.

   Those students who expressed greater enjoyment in the study of mathematics tended to have higher achievement scores. Achievement scores were also higher for those students who placed greater importance on the study of mathematics, and for those students who indicated that mathematics was easy to learn.

   It was recommended that curriculum developers and teachers be cognizant of the relationship between attitudes and achievement.

2. Student Achievement and Teacher Background.

   At grade 10, achievement scores tended to be higher for students who had teachers with the following characteristics:

   - had more teaching experience.
   - attended more mathematics conferences and workshops.
   - took more mathematics courses and more mathematics methods courses at university.
   - taught mathematics for a larger portion of their teaching load.

   At grade 7 the variables that were positively related to achievement were attendance at workshops, number of mathematics education courses, and proportion of teaching load. At grade 4, only attendence at workshops had a positive correlation with achievement.

   It was recommended that the practice of assigning non-specialist teachers to teacher secondary mathematics be reviewed and avoided whenever possible.

3. Student Achievement and Teaching Practices.

Student achievement tended to be higher for classes in which teachers employed the following:

- taught a greater number of problem-solving stategies.
- used a larger number of different sources for problem-solving exerises.
- assigned a greater variety of problem types.
- used a larger number of different kinds of motivational techniques (for grades 7 and 10 only).

It was recommended that teacher flexibility be encouraged through the provision of workshops on alternate approaches to teaching mathematics and through the development of resource books.

4. Student Achievement and Teacher Opinion.

Student achievement tended to be higher in classes where teachers indicated that they liked teaching mathematics, that mathematics was important, and that mathematics was easy to teach.

5. Student Opinion and Teacher Opinion.

Students tended to have more positive opinions about mathematics in classes where the teacher expressed positive opinions.

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# CHAPTER 1
# BACKGROUND AND ORGANIZATION OF THE STUDY

## The 1985 Provincial Assessment of Mathematics

The 1985 Assessment of Mathematics was the third in a series of large-scale mathematics assessments administered at four-year intervals in British Columbia schools. During May, 1985 all students enrolled in Grades 4, 7 and 10 wrote test booklets consisting of achievement items, background questions, and an attitude scale. At the same time, teachers completed a questionnaire which included questions about their backgrounds, opinions about topics in the curriculum, and activities and processes employed in their classrooms.

Several groups participated in the design and execution of the 1985 Mathematics Assessment. In addition to approximately 80,000 students and their teachers, these included the staff of the Student Assessment Branch of the Ministry of Education, members of the Contract Team, personnel from the Educational Research Institute of British Columbia (ERIBC), as well as members of the Provincial Advisory Committee, the Technical Sub-Committee, Review Panels, and Interpretation Panels.

The major instruments utilized in the Assessment consisted of three student test booklets at each grade level, randomly assigned on a one-per-student basis, and a teacher questionnaire. Each test booklet contained a set, of common background questions, one of three attitude scales and 50 achievement items designed to measure achievement on each of seven content domains. The teacher questionnaire contained a series of questions from each of four major areas: background information, perceptions of mathematics, problem-solving processes, and calculators and computers. A detailed description of these instruments can be found in the British Columbia Mathematics Assessment 1985: General Report (Robitaille & O'Shea, 1985).

The design of the 1985 Mathematics Assessment included the assignment of common code numbers to the response forms for teachers and students in their classes. This feature made it possible to link teachers' responses with the achievement results from their classes. Through examination of these linkages it was possible to investigate relationships between classroom processes and student achievement in mathematics.

## Purpose of the Study

The main objective of the present study was to examine the relationships among those classroom processes, teachers' behaviors, and teachers' and students' opinions about mathematics which might have significant effects on student

achievement in mathematics at the Grades 4, 7 and 10 levels. The findings from this process should contribute to the development of guidelines for the effective teaching of mathematics, and such guidelines might assist in providing direction for course planning, pre-service and in-service education of teachers, and in the selection of teaching approaches in mathematics.

A number of questions of interest to decision-makers were addressed in this study. Answers to these might provide direction for the alteration of classroom processes and the scheduling of both pre-service and in-service activities, whereas others might identify areas for further research. The specific questions addressed were the following:

1. What relationships exist between classroom organizational variables such as use of tests, length of period, homework activities, seatwork, questioning techniques, use of drill, and small group activities and student outcomes?

2. What relationships exist between teacher background variables, such as experience, number of mathematics education courses taken, and attendance at workshops and student achievement?

3. What relationships exist between problem-solving processes such as the number of different strategies taught, and teachers' attitudes toward the topic and student achievement?

4. What relationships exist between teachers' opinions of the importance, difficulty and enjoyment of teaching mathematics and student achievement?

5. What relationships exist between students' opinions of the importance, difficulty and enjoyment of learning mathematics and their achievement?

6. What are the relative effects of the inputs listed in Questions 1 to 5 above on student achievement?

7. What differences, if any, can be found in results based on the analysis of survey information when a pre-test is included in the design?

Responses to questions 1 to 6 were addressed through further analysis of results from the 1985 Provincial Assessment of Mathematics. However, since that assessment did not include the administration of a pre-test, an answer to question 7 was based on a subsequent study conducted during the 1986-87 school year. In the latter study a large urban

district replicated the 1985 Assessment at the Grade 7 level with the addition of a pre-test.

## Overview of the Study

The design of the 1985 Assessment provided an opportunity to link teacher questionnaire responses with class results. This was made possible through the assignment of common class codes to teachers and students. Further analysis of the data makes it possible to determine relationships between various teaching strategies, types of classroom organization, students' and teachers' opinions of mathematics, and achievement. Data for the teacher-related variables were taken from responses to the teacher questionnaire. Student achievement and background information was drawn from responses of students to achievement test items and the *Mathematics in School* scale.

Responses of those students whose teachers completed the teacher questionnaire were re-scored and aggregated to the classroom level. Class means were then calculated and linked to the responses of teachers. Correlations between class achievement and attitude, and teacher background and classroom process variables were determined at the next stage of analysis.

# CHAPTER 2
# RESEARCH ON STUDENT ACHIEVEMENT IN MATHEMATICS

Direction for the selection of variables to be examined and for the techniques to used in this study was gained through a review of related research. This chapter outlines some of the problems associated with early research studies, discusses changes in methodology employed in more recent work and identifies a number of relationships between the inputs of schooling and student achievement to be given further examination.

## Early Studies on Teacher Effectiveness

Research conducted on effective teaching prior to the mid 1970s found little evidence that teachers or schools made a difference in student achievement. For example, in a review of more than 10 000 studies on teacher effectiveness, Gage (1960) reported that the combined literature was overwhelming in its inconsistencies. Similar conclusions were drawn in subsequent reviews of the literature by Fey (1969), Jencks et al. (1972), and Dunkin and Biddle (1974).

Many of these early studies concluded that student background and ability accounted for almost all measurable variance in student achievement. The message they delivered was, in spite of commonly held perceptions that some teachers were more effective than others, that teachers and schools made little if any appreciable difference in student achievement levels. This finding did not appear logical yet the analysis of results led to this conclusion.

Later work in this area, however, led to the identification of a number of weaknesses in the design and analysis procedures employed in many of the earlier studies. Most data collected on teachers focused only on their background qualities. For example, in a study of relationships between over 400 input variables and achievement outcomes, Coleman et al. (1966) reported that variables which could be manipulated by school policies such as teacher salaries, type of curriculum, and per pupil expenditures had little effect on student achievement. Other problems associated with a number of these early studies related to the difficulty of separating the effects due to school resources and family background (Bowles & Levin, 1968), the use of achievement tests not linked directly to the curriculum (Postlethwaite, 1975), and techniques used in dealing with aggregated data (Burstein, 1980).

## Later Research

Later studies identified a number of features of school climate and teacher behaviors which were found to correlate significantly with student achievement. These findings resulted not only from improvements in the instruments and statistical techniques used in the early studies, but also from a change in the focus on teacher inputs. This focus shifted from background variables to the examination of teaching styles, classroom management techniques, and interactions between students and teachers.

In a review of almost 300 of these second-generation studies, Medley (1979), found that elementary teachers producing the greatest long-term gains in achievement employed the following practices: more student time on task (time was gained by spending less of it on classroom management routines, and through teaching the class as a whole or in large groups), less independent seatwork, and greater emphasis on academic achievement. This pattern of teaching, classified as direct instruction, was found to be the best way to ensure that students mastered the basic skills. Rosenshine (1979), lists the following five principles of effective instruction:

1. academic focus
2. teacher selection and direction of activities
3. grouping of students for instruction
4. demonstration-practice-feedback process
5. mastery

Stallings (1976), in a study of classroom processes and instructional practice, found that the classroom process variable which correlated best with achievement was student time engaged in mathematical activities. Emphasis placed on drill, follow-up to homework, and small group instruction were among other positive relationships found.

Further evidence of the importance of time spent on mathematical activities has been found in numerous other studies. (Husén, 1967; Stallings & Kaskowitz, 1974; McDonald & Elias, 1976). Berliner (1978), however, made an important distinction among types of time-related activities. He defined three variables: allocated time, engaged time and academic learning time.

In a study by Wiener (1979) it was found that the most effective teachers of mathematics at the Grades 2 and 3 levels used subgroup teaching for the presentation of new skills to accelerate students and for general review to remediate students. This finding was supported by results of a study of Grade 4 students by Sindelar et al. (1984) in which it was found that students working in small groups increased engaged

time, and engaged time was related to student achievement. Further evidence of the importance of grouping is provided in studies by Moody et al. (1974) and Fisher et al. (1980), where it was found that small group sizes had considerable influence on learning due to the maximization of some variables, such as teacher interaction time, which are related to achievement.

# CHAPTER 3
# DESCRIPTION OF THE VARIABLES

The variables examined in this study were classified into two major categories. Those used to measure student achievement were considered as products or outputs, whereas variables which measured teachers' and students' backgrounds and opinions were considered as the inputs of the system.

## Outputs of the System

Student achievement was defined as performance on the total test. This variable was a measure of the overall performance of students in mathematics. It consisted of class means based on achievement in the five curricular domains used in the 1985 Mathematics Assessment. These domains were Number and Operation, Geometry, Measurement, Algebraic Topics and Problem Solving. Results from the two non-curricular domains contained in the 1985 study, probability and statistics and calculators and computers, were not included in these analyses.

## Input Variables

Inputs of the system, for the purposes of this study, consisted of variables shown by previous research to relate to student achievement. As mentioned earlier, these variables were clustered under the following categories: student and teacher backgrounds, students' and teachers' opinions of mathematics, classroom organization and problem-solving processes. A list of these variables is given below.

**Variables**

A. Student Backgound

1. Language first spoken
2. Language spoken at home
3. Time on math homework
4. Father's education level
5. Mother's education level

B. Teacher Background

1. Years of experience
2. Preference to teach mathematics
3. Proportion of teaching load
4. Professional development
5. Professional training

C. Students' Opinions of Mathematics

1. Importance of mathematics
2. How easy mathematics is to learn
3. How enjoyable mathematics is to learn

D. Teachers' Opinions of Mathematics

1. Importance of mathematics
2. How easy mathematics is to teach
3. How enjoyable mathematics is to teach

E. Classroom Organization

1. Type of course
2. Frequency of testing
3. Number of classes per week
4. Length of period
5. Time spent on homework
6. Questioning techniques
7. Seatwork
8. Working in small groups
9. Working at activitiy stations
10. Computational drill
11. Giving lecture style instruction

G. Problem-Solving Processes

1. Teacher expectations
2. Teacher efficacy
3. Uses of different strategies
4. Involvement in In-service
5. Uses of material resources
6. Activities for motivation
7. Frequency of teaching
8. Problem types used

Relationships among variables within each category and between these variables and student achievement on test total were examined at a subsequent stage of analysis using Pearson Product-Moment Correlations. Following a review of these correlations, a factor analysis was conducted among the variables within each input category to determine the extent to which they measured the same attributes. Based on these results, the number of items in each category was reduced. The outcomes of this process are presented in Chapter 7, where relationships between inputs and outcomes are discussed.

## Aggregation of Data

Since the study was designed to investigate relationships between behaviors of teachers and achievement in their

classes, it was necessary to aggregate student results to the classroom level. A description of how this was done follows.

Means and standard deviations by achievement domain were aggregated to the class level. Since each of the three assessment bookets contained different achievement items, statistics were calculated using the number of items attempted by each student. The "I don't know" response was included in the determination of these reported scores, consistent with past practice for provincial assessments in British Columbia and a number of other jurisdictions. Since each student responded to only one out of every three items, the class statistics which were calculated were estimated means.

The options students selected for background items were assigned numerical values first. Then class means were calculated by summing the weighted values of the responses and dividing by the number of respondents. To determine total scores for students' opinions of mathematics, ratings for each of the ten major topics in the curriculum were added together.

Teachers' responses were also assigned numerical weightings. The value assigned to each teacher for single-response items was equivalent to the weighting given the option chosen. For multiple-response items, each option was assigned a value of 1 if it was chosen, or a 0 if it was not. The score for each of these items was arrived at by adding the score for all responses.

The weights assigned to options for each item are shown in Appendix A. Those items which required multiple reponses are also identified.

# CHAPTER 4
# TEACHERS OF MATHEMATICS

In this chapter a detailed account of teachers' backgrounds and opinions about mathematical topics, classroom organization, and uses of problem-solving processes is provided. Each of these features is discussed relative to the variables under examination. A comparison of responses across grade levels is also included for comparison purposes.

## Teacher Background

The variables in this category included years of experience, preference to teach mathematics, proportion of teaching load, and professional development and training. For most questions teachers selected one of five options. For reporting purposes, however, responses to some questions have been collapsed into 2 or 3 categories.

### Years of Experience

Information for this variable was based on responses to the question, "For how many years will you have been teaching mathematics as of June 1985?" Results are shown in Table 1.

**Table 1**
**Teaching Experience**
**(percent)**

| Years of Experience | Grade Level 4 | 7 | 10 |
|---|---|---|---|
| 1-2 | 7 | 7 | 14 |
| 3-10 | 38 | 40 | 30 |
| 11 or more | 55 | 53 | 56 |

Although the proportion of experienced teachers of mathematics at each of the 3 grade levels is similar, there is a striking difference in the percentages of teachers with two or fewer years of experience between teachers of Grade 10 and the other two grade levels. For example, 14 percent of teachers are in either their first or second year of mathematics teaching at that grade level compared to only 7 percent at the other two. This difference, which has taken place in a shrinking job market for secondary teachers, could

be an indicator of the extent to which secondary teachers, trained in disciplines other than mathematics, have been assigned to teach mathematics classes.

**Preference to Teach Mathematics**

Teachers were asked the following question regarding their opinion about teaching mathematics, "If you had a choice, would you avoid teaching mathematics altogether?" Results are shown in Table 2.

**Table 2**
**Teacher Preference to Avoid Teaching Mathematics**
**(percent)**

| Response | Grade Level 4 | 7 | 10 |
|---|---|---|---|
| Yes | 3 | 4 | 10 |
| No | 95 | 94 | 87 |
| Undecided | 2 | 2 | 3 |

These results show that the vast majority of teachers at Grades 4 and 7 prefer to teach mathematics. However, it is significant that 10 percent of teachers at the Grade 10 level prefer not to teach the subject at all. This is more than three times the proportion of teachers with a similar preference at the Grade 4 level and more than twice that at Grade 7. It seems likely that these results are another indicator of the re-deployment of teachers suggested in the preceding section.

**Proportion of Teaching Load**

Results for this variable are shown in Table 3. The question teachers responded to was as follows: "What percent of your current teaching load is mathematics?"

The low proportion of total time spent on teaching mathematics at Grades 4 and 7 is not unexpected since most elementary teachers teach several subject areas. On the other hand, it is clear at the Grade 10 level that teachers specialize to a much greater extent.

**Table 3**
**Mathematics Teaching Load**
**(percent)**

| Proportion of Time | Grade Level 4 | 7 | 10 |
|---|---|---|---|
| 0-20% | 64 | 63 | 19 |
| 21-60% | 35 | 34 | 26 |
| 61-80% | 1 | 1 | 11 |
| 81-100% | - | 2 | 45 |

**Professional Development**

Two questions in this area dealt with attendance at a mathematics session, either at a conference or a workshop within the previous three years. Fifty six percent of the teachers at Grade 10 had attended a mathematics session at a conference during that time compared with 50 and 49 percent of teachers at Grades 4 and 7, respectively. Responses to the question on attendance at a mathematics workshop within the previous three years showed a similar pattern with affirmative responses of 58, 59, and 62 percent from teachers of Grades 4, 7, and 10, respectively.

Results show that a slightly greater percentage of teachers of Grade 10 mathematics attended in-service sessions than did those at the other two grade levels. This is not unexpected since it is likely that the majority of the teachers at that level are mathematics specialists.

**Professional Training**

Teachers were asked two questions related to their professional background. The first dealt with the number of mathematics courses completed, while the second question asked about the number of methods courses in mathematics education. Each course was equivalent to one and one-half units at the University of British Columbia. The responses are reported in Tables 4 and 5.

**Table 4**
**Mathematics Courses Completed**
**(percent)**

| Number of Courses | Grade Level 4 | 7 | 10 |
|---|---|---|---|
| 0 | 32 | 23 | 5 |
| 1 or 2 | 42 | 40 | 21 |
| 3-5 | 19 | 25 | 19 |
| 6 or more | 7 | 12 | 55 |

The information shown in Table 4 raises a particular concern at the Grade 10 level. It shows, for example, that 26 percent of teachers of mathematics at the Grade 10 level have completed 2 or fewer half-year courses in post-secondary mathematics. This is likely a further result of the re-deployment of teachers trained in other areas to teach mathematics. Another striking observation is that less than 55 percent of these secondary teachers have completed enough courses to qualify for a mathematics major.

**Table 5**
**Mathematics Methods Courses Completed**
**(percent)**

| Number of Courses | Grade Level 4 | 7 | 10 |
|---|---|---|---|
| 0 | 18 | 22 | 27 |
| 1 or 2 | 67 | 61 | 45 |
| 3-5 | 12 | 13 | 17 |
| 6 or more | 3 | 4 | 11 |

Results shown in Table 5 identify an even greater problem related to professional preparation at all three grade levels. They show that 18, 22, and 27 percent of teachers at Grades 4, 7, and 10, respectively, have taken no mathematics methods courses at all.

## Teachers' Opinions of Mathematics

In order to gain some insight into teachers' opinions of topics in the curriculum, they were also asked to rate the importance, difficulty, and enjoyment of teaching major topics in the curriculum at each of the three grade levels. Responses were on five point scales ranging from "not at all important" to "very important" for the importance rating; from "very difficult" to "very easy" for the difficulty to teach rating; and from "dislike a lot" to "like a lot" for the enjoyment to teach rating. Results, showing proportions who chose the two most positive options in each rating, are displayed in Table 6, 7, and 8.

**Table 6**
**Grade 4 Teachers' Opinions about Selected Topics**
**(percent)**

| Topic | Very Important or Important | Easy or Very Easy | Like a lot or Like |
|---|---|---|---|
| Whole numbers | 99 | 65 | 95 |
| Decimals | 74 | 45 | 71 |
| Fractions | 75 | 50 | 80 |
| Metric system | 92 | 54 | 74 |
| Estimation | 86 | 45 | 69 |
| Polygons | 77 | 81 | 86 |
| Checking Answers | 94 | 37 | 54 |
| Using graphs | 86 | 74 | 88 |
| Word problems | 22 | 98 | 76 |
| Place Value | 97 | 48 | 82 |

### Grade 4 Teachers

A large majority of Grade 4 teachers rated all topics as important, ranging from 74 percent for Learning About Decimals to 99 percent for Operations With Whole Numbers. Only 22 percent however, rated teaching the Solution of Word Problems as easy to teach. This contrasted with the importance of the topic, where 98 percent rated it important or very important.

Other topics which teachers found difficult to teach were Checking Answers, Estimation, and Decimals. The topic they enjoyed teaching most was Operations With Whole Numbers, which 95 percent rated as enjoyable to teach. The topic they least enjoyed teaching was Checking Answers. Only 54 percent rated it positively.

**Table 7**
**Grade 7 Teachers' Opinions about Selected Topics**
**(percent)**

| Topic | Very Important or Important | Easy or Very Easy | Like a lot or Like |
|---|---|---|---|
| Fractions | 81 | 85 | 50 |
| Decimals | 98 | 75 | 94 |
| Percents | 96 | 48 | 92 |
| Estimation | 85 | 41 | 66 |
| Basic Facts | 90 | 57 | 52 |
| Equations | 94 | 36 | 86 |
| Word Problems | 96 | 16 | 75 |
| Metric System | 92 | 45 | 67 |
| Perimeter and Area | 84 | 64 | 85 |
| Geometry | 71 | 55 | 83 |

**Grade 7 Teachers**

Importance ratings for topics at the Grade 7 level ranged from a low of 71 percent for Doing Geometry to a high of 94 percent for Solving Word Problems. Teachers reported that the most difficult topics to teach were Solving Word Problems and Solving Equations, while Operations With Decimals was reported as the easiest. It is interesting to note that although Solving Word Problems was reported as the most difficult to teach (only 16 percent found it easy), 75 percent enjoyed teaching the topic.

**Table 8**
**Grade 10 Teachers' Opinions about Selected Topics**
**(percent)**

| Topic | Very Important or Important | Easy or Very Easy | Like a lot or Like |
|---|---|---|---|
| Equations | 93 | 51 | 88 |
| Area and Volume | 80 | 66 | 70 |
| Fractions, Decimals and Percent | 92 | 48 | 61 |
| Factoring | 76 | 47 | 75 |
| Geometric Figures | 35 | 53 | 58 |
| Exponents | 81 | 55 | 76 |
| Graphs | 82 | 61 | 80 |
| Estimation | 79 | 37 | 52 |
| Word Problems | 94 | 13 | 75 |
| Congruent and Similar Figures | 49 | 41 | 59 |

**Grade 10 Teachers**

The range of responses to topic ratings at this level was considerably greater than at either of the other two. Importance ratings ranged from a low of 35 percent for Constructing Geometric Figures to a high of 94 percent for Solving Word Problems. The high importance rating given to Word Problems contrasted dramatically with its difficulty to teach rating. For example, while 94 percent rated it as important, only 13 percent found this topic easy to teach. Eighty-eight percent of teachers at this level found Solving Equations to be the most enjoyable topic to teach but only 51 percent found it easy. It will be shown in the following chapter, that these wide variances among opinions of topics are shared by the students of these teachers.

## Classroom Organization

Teachers responded to four questions related to classroom organization. The variables examined included type of course, frequency of testing, number of classes per week and length of period. The question on course type asked teachers to identify whether their responses related to a class of students on a regular, enriched, or modified program. Their results are reported in Table 9.

**Table 9**
**Type of Course**
**(percent)**

| Course Type | Grade Level 4 | 7 | 10 |
|---|---|---|---|
| Regular | 88 | 90 | 63 |
| Modified (slower students) | 8 | 6 | 24 |
| Enriched | 4 | 4 | 13 |

Grade 10 results contrasted sharply with the official curriculum guide in which streaming is not recognized. For example, 37 percent of teachers responded on behalf of a modified or an enriched class. Results from Grades 4 and 7 were similar to one another: the vast majority of classes were reported to be regular.

Teachers were also asked how often they gave tests or quizzes to their classes. Results are shown in Table 10.

These results show that tests and quizzes play an important role in the mathematics program at each grade level. For example, 60, 56, and 48 percent of the teachers at Grades 4, 7, and 10, respectively, test at least once every week. The remainder test at least every couple of weeks.

Most teachers of Grades 4 and 7 scheduled five mathematics classes each week. Eighty-three percent at Grade 4 and 72 percent at Grade 7 indicated that mathematics is a daily activity. At the Grade 10 level, however, the majority of teachers offer mathematics three times each week. This is likely due to secondary school organizations which are not on five-day timetable cycles.

**Table 10**
**Frequency of Testing**
**(percent)**

| Testing Times | Grade Level 4 | 7 | 10 |
|---|---|---|---|
| Almost Every Day | 20 | 11 | 10 |
| Once a Week | 40 | 45 | 38 |
| Once Every Couple of Weeks | 38 | 43 | 51 |
| Once Every Reporting Period | 1 | 1 | 1 |
| Almost Never | 1 | - | - |

Lengths of mathematics periods increase with grade level. In the fourth grade 71 percent of the teachers spend between 31 and 45 minutes on each class period and 27 percent spend longer. At the Grade 7 level, 58 percent spend an equivalent amount of time on each class and 40 percent spend longer. Only 3 percent of teachers at Grade 10 spend 45 minutes or less on each class period. The vast majority spend between 46 and 60 minutes. The longer periods at Grade 10 correspond with fewer classes each week.

Six questions on the teacher questionnaire related to the amount of time teachers spent in their most recent mathematics period on various types of classroom activities. The proportions of class time spent on these activities are shown in Table 11.

A comparison of classroom processes across grade levels shows similar practices in the proportions of time spent on seatwork, working in small groups, working at stations or activity centers, and in explaining new topics. Differences in time allotments, however, are apparent with homework-related activities and computational drill. The proportion of class time spent on computational drill decreases in each successive grade level. For example, 73 percent of Grade 10 teachers spent no time on this activity in their most recent class compared to 51 percent at Grade 7 and 26 percent at Grade 4. Differences in the amount of time spent on homework-related activities follows an expected trend with 24, 9 and 6 percent of teachers at Grades 4, 7 and 10 respectively, spending no time on activities in this area.

**Table 11**
**Time Spent on Classroom Activities**
**(percent)**

| Activity | Grade 4 | | | | Grade 7 | | | | Grade 10 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0% | 1-25% | 26-75% | 76-100% | 0% | 1-25% | 26-75% | 76-100% | 0% | 1-25% | 26-75% | 76-100% |
| Homework | 24 | 73 | 3 | - | 9 | 82 | 8 | 1 | 6 | 83 | 11 | - |
| Seatwork | 2 | 23 | 70 | 5 | 2 | 29 | 65 | 4 | 2 | 25 | 67 | 6 |
| Grouping | 57 | 36 | 5 | 2 | 57 | 36 | 5 | 2 | 58 | 35 | 6 | 1 |
| Activity Centers | 82 | 17 | 1 | - | 91 | 8 | 1 | - | 92 | 7 | 1 | - |
| Drill | 26 | 68 | 5 | 1 | 51 | 46 | 3 | - | 73 | 25 | 2 | - |
| New Topics | 16 | 64 | 19 | 1 | 12 | 64 | 23 | 1 | 15 | 57 | 27 | 1 |

## Problem-Solving Processes

Scale S on the Teacher Questionnaire dealt with a number of teachers' opinions and practices related specifically to the teaching of problem solving. Included in this section were questions related to teachers' expectations of students, their attitude toward problem solving, the strategies they taught and the classroom practices they employed in teaching this topic.

### Teachers' Expectations

When asked if their students enjoyed problem solving 36 percent of Grade 4 teachers agreed, compared to 28 and 18 percent of teachers at Grades 7 and 10, respectively. The decrease in perceived student enjoyment of problem solving at successive grade level was consistent with teachers' expectations of their students' performance. For example, when asked if their students performed well in problem solving only 24 percent of Grade 10 teachers agreed, compared to 28 and 33 percent at Grades 7 and 4, respectively.

### Teachers' Attitudes

Teachers' attitude toward the topic of problem solving was measured by questions which asked if they were satisfied

with their teaching of the topic and how easy they found it to teach. Fifty-seven percent of Grade 10 teachers felt positively toward their performance in teaching the topic compared with 45 percent at Grade 7, and 47 percent at Grade 4. Teachers at all three levels did not find it easy to teach with only 21, 17 and 19 percent giving positive responses at Grades 4, 7 and 10, respectively.

## Strategies Used

In order to determine which strategies for problem solving were taught to students, teachers were asked to identify all of those, from a selection of five different strategies, which they taught. The percentage who taught each strategy is reported in Table 12. Since this was a multiple-response item, the number of different strategies taught by teachers is reported in Figure 1 which follows later.

**Table 12**
**Problem-Solving Strategies Taught by Teachers**
**(percent)**

| Strategy | Grade Level 4 | 7 | 10 |
|---|---|---|---|
| Look for a Pattern | 84 | 84 | 75 |
| Guess and Check | 37 | 42 | 30 |
| Make a List or Table | 63 | 70 | 79 |
| Solve a Simpler Problem | 63 | 72 | 65 |
| Work Backwards | 38 | 46 | 28 |

These results show that Look For A Pattern is the most frequently taught strategy overall, while Guess and Check and Work Backwards are the least popular ones. Eighty-four percent of teachers at Grades 4 and 7, and 75 percent at Grade 10 taught the most popular strategy while the two least popular strategies were taught by between 28 and 46 percent of teachers across grade levels.

Since teachers were asked to check all strategies they taught, information on the number of different strategies is also available. Results are illustrated in Figure 1.

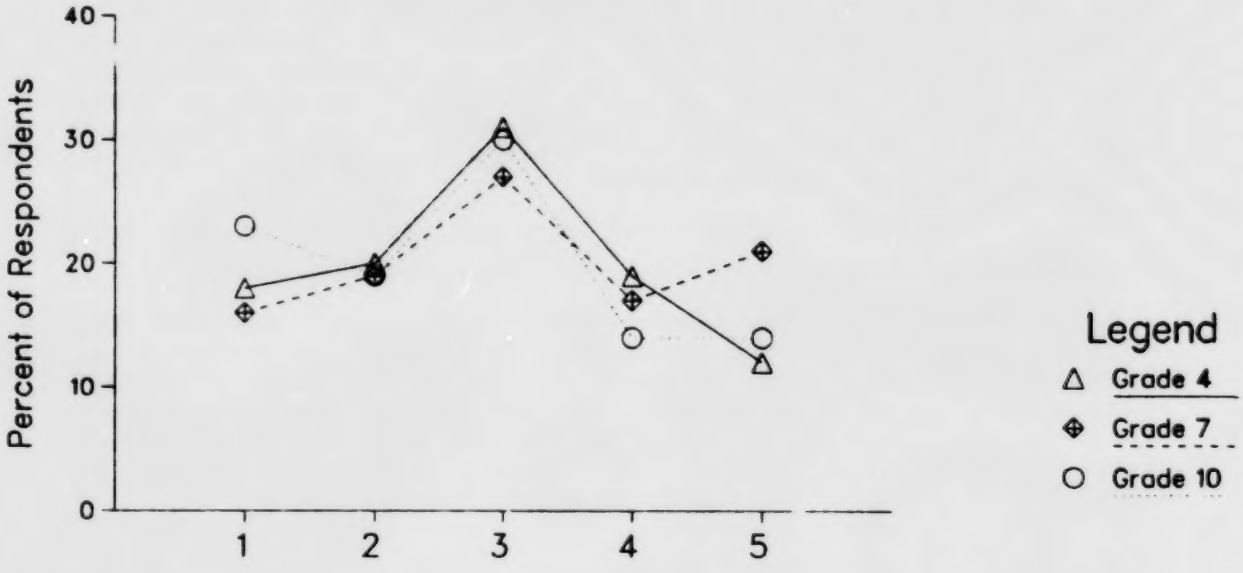


Figure 1. Number of strategies taught.

Twenty-one percent of Grade 7 teachers indicated that they taught all five of the strategies. This compared with 12 percent at Grade 4 and 14 percent at Grade 10. Teachers at the Grade 10 level taught fewer strategies in total than those at the other grade levels. For example, 42 percent taught only one or two strategies compared to 38 percent at Grade 4 and 35 percent at Grade 7. Relationships between the performance of students on the problem-solving domain and the number of different strategies taught by teachers are examined in Chapter 7.

**In-service Activities**

Results for this variable were based on responses to a question on attendance at problem-solving workshops during the previous year. Results showed that 73, 72, and 77 percent of teachers at Grades 4, 7, and 10 had not attended any workshops on this topic during the previous year. Only 6, 8, and 6 percent of teachers attended 2 or more workshops. There seems to be a need for more involvement with in-service in this area, particularly in view of the recently revised curriculum with its emphasis on problem solving.

## Sources of Exercises

Teachers were asked which sources they used for problem-solving exercises. Table 13 shows the percentage of teachers who reported using each of the listed sources whereas Figure 2, which follows later, illustrates how many of these different sources were reported by teachers.

**Table 13**
**Sources for Problem Solving Exercises**
**(percent)**

| Source | Percentage of Teachers Grade 4 | Grade 7 | Grade 10 |
|---|---|---|---|
| Textbook | 94 | 93 | 92 |
| Mathematics Contests | 25 | 37 | 39 |
| Problem-Solving Booklets | 72 | 67 | 53 |
| Professional Journals | 19 | 19 | 18 |
| Books of Puzzles | 64 | 59 | 42 |

Table 13 shows that the textbook is, by far, the most popular source of problem-solving exercises. More that 90 percent of teachers at each grade level used it for that purpose. The least popular source was the professional journal for which fewer than 20 percent of teachers across grade levels access it as a resource for exercises.

The number of different sources of problem-solving exercises used by teachers is shown in Figure 2.

Results show that teachers of Grade 10 used fewer sources than either of the other grade levels. Although 8 percent of Grade 10 teachers used all five sources compared to 6 and 4 percent respectively at Grades 4 and 7, a greater proportion of teachers at this grade level used only one or two sources than those at the other two grades. For example, 55 percent of Grade 10 teachers used only one or two of the sources, compared to 40 and 38 percent of those at Grades 7 and 4.

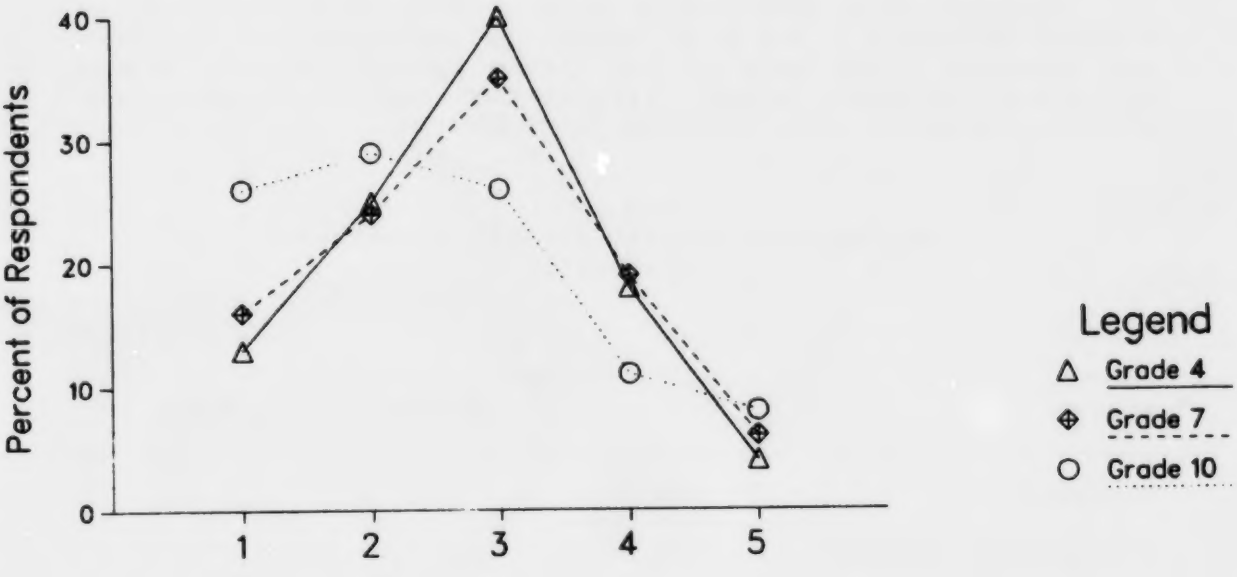


Figure 2. Number of references used for problem solving.

**Motivational Activities**

To determine which activities were utilized to motivate students, teachers were asked to identify, from a list of five, all of those they used in the classroom. The proportion of teachers who selected each option is shown in Table 14.

With the exceptions of Problem of the Week and Bulletin Board Display, greater proportions of teachers of Grades 4 and 7 used these activities than did those at Grade 10. For example, only 30 percent of Grade 10 teachers used Student-Authored Problems compared to 64 percent at Grade 4 and 52 percent at Grade 7.

**Table 14**
**Problem Solving Activities**

| Activity | Percentage of Teachers Grade 4 | Grade 7 | Grade 10 |
|---|---|---|---|
| Problem-Solving Center | 20 | 14 | 8 |
| Bulletin Board Display | 14 | 15 | 23 |
| Problem of Week | 33 | 36 | 40 |
| Contests Within Class | 46 | 52 | 40 |
| Student-Authored Problems | 64 | 52 | 30 |

The number of these different activities used by teachers is shown in Figure 3.

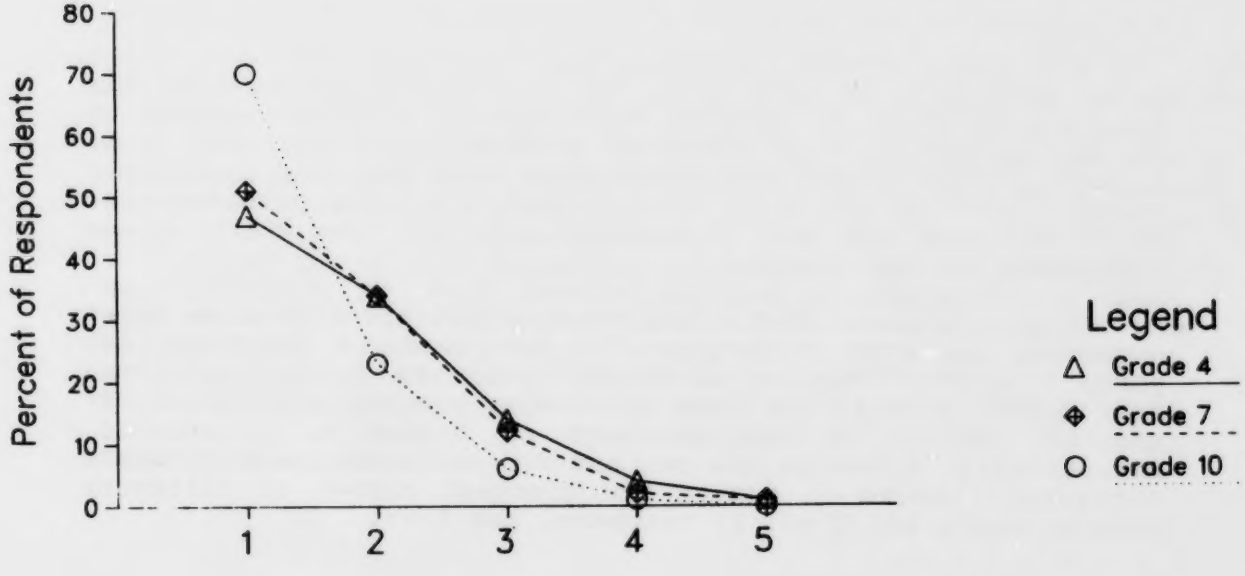


Figure 3. Number of motivational activities used.

**Types of Problems Assigned**

Given five different types of problems, teachers were asked to identify the ones they gave to students to solve. The proportions of teachers who assigned each problem type are shown in Table 15. The number of different types of problems given, on the other hand, are reported in Figure 4.

**Table 15**
**Types of Problems Assigned**

| Problem Types | Percentage of Teachers | | |
|---|---|---|---|
| | Grade 4 | Grade 7 | Grade 10 |
| More than one answer | 33 | 35 | 38 |
| Requires data collection | 67 | 59 | 48 |
| Can be solved in more than one way | 80 | 89 | 89 |
| Collectively solved | 40 | 43 | 31 |
| Too much or little information | 45 | 64 | 42 |

The most popular problem type assigned was one which could be solved in more than one way. Eighty percent of the teachers at Grade 4 assigned this type of problem whereas 89 percent assigned it at each of Grades 7 and 10. The least popular problem types were those with more than one answer and those solved collectively. It is likely that the problem types which were assigned most frequently were the ones which appear most often in the textbook.

Figure 4 shows that three or more different problem types were assigned by 51 percent of the Grade 4 teachers, 60 percent of the teachers of Grade 7, and 45 percent of those from Grade 10. Only one type of problem was assigned by 19, 14 and 22 percent of the teachers in Grades 4, 7 and 10, respectively. Although the pattern did not vary greatly, Grade 7 teachers tended to assign the greatest number of different problem types and Grade 10 teachers, the least.

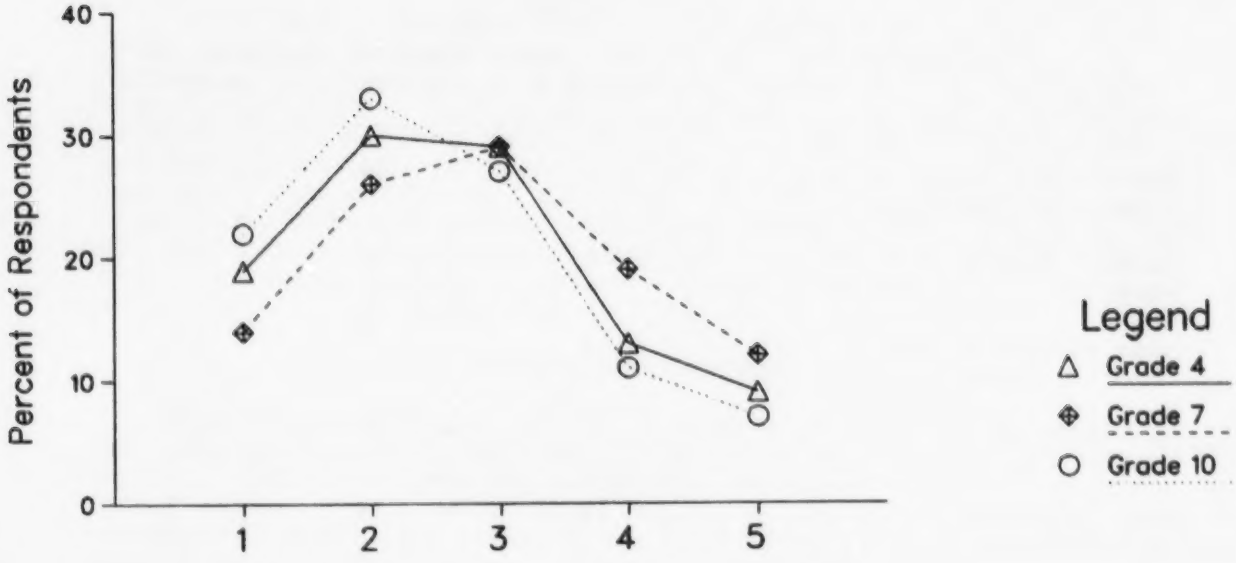


Figure 4. Number of problem types assigned.

**Frequency of Teaching**

Teachers were asked a question on the frequency with which they taught the topic of problem solving. Results are shown in Table 16.

Based on this information it seems the most frequently used approach to teach problem solving at the Grade 10 level was as a unit from time to time. At Grades 4 and 7 it was taught most frequently on a daily basis. Although 28 percent of the Grade 10 teachers also indicated it was taught daily, it is not surprising that the majority of teachers at this level do not teach it that frequently due to different timetable organizations at the secondary level.

**Table 16**
**Frequency of Teaching Problem Solving**

| Frequency | Percentage of Teachers | | |
|---|---|---|---|
| | Grade 4 | Grade 7 | Grade 10 |
| As a unit from time to time | 21 | 24 | 46 |
| Almost every day | 34 | 38 | 28 |
| One period every 2 or 3 weeks | 11 | 6 | 3 |
| At the end of a major topic | 16 | 18 | 18 |
| One period a week | 18 | 14 | 5 |

# CHAPTER 5
# STUDENT OUTCOMES

The main purpose of this study was to examine relationships between the inputs of schooling and student outcomes. In Chapter 4 a number of inputs related to teacher behaviors were discussed. They included teachers' backgrounds, opinions of mathematics, classroom organization, and approaches to the teaching of problem solving. In this chapter, descriptions of the student populations are discussed. Information on students' backgrounds, opinions of mathematics and achievement levels is provided. In a later chapter relationships between these teacher and student variables will be examined.

## Student Background

The student background variables which were examined included a surrogate measure of socio-economic status, mother tongue, and time spent on homework. Questions which related to these areas dealt with the following topics: fathers' and mothers' levels of education, language first spoken and currently spoken in the home, and time spent on mathematics homework.

In responding to the questions on mother tongue students were asked to identify the highest levels of education attempted by their parents or guardians. The options from which they chose were the following: very little or none, elementary, secondary, some form of post-secondary, and did not know. Results showed that almost half of the students did not know. Of those who indicated a knowledge of their parents' educational level the most popular options were either secondary or post-secondary. For example, at the Grade 7 level 45 percent of the students selected the secondary option and 49 percent selected post-secondary for mother's or female guardian's level of education. Similar results were found for the father or male guardian.

The two questions which related to mother tongue asked students which language they first spoke and which language was currently spoken in the home. Options for these questions were English, French and Other. Results are shown in Table 17.

A larger proportion of Grade 10 students first spoke a language other than English or French than did those at Grades 4 or 7. Of those who first spoke a language other than English, approximately one half no longer speak that language at home.

**Table 17**
**Language Spoken**
**(percent)**

| | Grade 4 | | Grade 7 | | Grade 10 | |
|---|---|---|---|---|---|---|
| | First Spoken | Currently Spoken in Home | First Spoken | Currently Spoken in Home | First Spoken | Currently Spoken in Home |
| English | 87 | 93 | 89 | 94 | 84 | 92 |
| French | 2 | 1 | 1 | 1 | 1 | 1 |
| Other | 11 | 6 | 10 | 5 | 15 | 7 |

The question on the amount of time students spent on their last homework assignment provided options ranging from none to more than one hour. Table 18 shows the proportions of students who selected each option.

**Table 18**
**Time Spent on the Last Mathematics Homework Assignment**
**(percent)**

| Amount of Time | Grade 4 | Grade 7 | Grade 10 |
|---|---|---|---|
| None. We have no homework | 9 | 4 | 6 |
| 1-10 minutes | 41 | 29 | 6 |
| 11-30 minutes | 36 | 52 | 19 |
| 31-60 minutes | 10 | 12 | 51 |
| more than 60 minutes | 4 | 3 | 18 |

The results show that students spent increased amounts of time on their last assignment at each of the three successive grade levels. These results are not surprising since provincial guidelines suggest that more time should be spent on homework at successive grade levels.

## Students' Opinions of Mathematics

Students were asked their opinions of the importance, difficulty to learn and enjoyment in learning experienced with the same topics asked of their teachers. Results, showing the proportions of students who chose the two most positive options in each category are shown in Tables 19 through 21, which follow:

**Table 19**
**Grade 4 Students' Opinions of Major Topics**
**(percent)**

| Topic | Very Important or Important | Easy or Very Easy | Like a Lot or Like |
|---|---|---|---|
| Whole Numbers | 93 | 63 | 77 |
| Decimals | 73 | 46 | 52 |
| Fractions | 87 | 64 | 72 |
| Metric System | 81 | 45 | 56 |
| Estimation | 69 | 58 | 61 |
| Polygons | 55 | 89 | 72 |
| Checking Answers | 90 | 77 | 53 |
| Graphs | 76 | 64 | 68 |
| Word Problems | 73 | 63 | 64 |
| Place Value | 81 | 55 | 58 |

Students at the Grade 4 level identified Operations With Whole Numbers as the most important topic as well as the one they enjoyed most. The topic they found easiest was Learning About Polygons. This topic, however, was rated as least important. Students at this level found the Metric System to be the most difficult with only 45 percent rating it as easy.

Grade 7 students felt that Operations With Fractions and Decimals were the two most important topics, followed closely by Working With Percents and Learning About the Metric System. They rated Solving Word Problems as both the least important and least enjoyable. The most difficult topic identified by students at this level was Learning About the Metric System.

**Table 20**
**Grade 7 Students' Opinions of Major Topics**
**(percent)**

| Topic | Very Important or Important | Easy or Very Easy | Like a Lot or Like |
|---|---|---|---|
| Fractions | 88 | 66 | 58 |
| Decimals | 88 | 70 | 62 |
| Percents | 86 | 56 | 58 |
| Estimation | 53 | 64 | 43 |
| Basic Facts | 83 | 56 | 41 |
| Equations | 84 | 67 | 58 |
| Word Problems | 60 | 43 | 37 |
| Metric System | 86 | 41 | 42 |
| Perimeter and Area | 72 | 51 | 46 |
| Geometry | 69 | 51 | 52 |

At the Grade 10 level students indicated that Working With Fractions, Decimals and Percent was the most important topics this contrasted with Working With Congruent and Similar Figures and Factoring which received low importance ratings. Students reported that Solving Word Problems was the most difficult topic, followed closely by Congruent and Similar Figures. These two topics also received the lowest ratings for enjoyment.

Results show that students' positive ratings for each of the importance, difficulty and enjoyment scales were lower at each successive grade level. At each grade importance ratings were consistently higher than were ratings of difficulty and enjoyment.

**Table 21**
**Grade 10 Students' Opinions of Major Topics**
**(percent)**

| Topic | Very Important or Important | Easy or Very Easy | Like a Lot or Like |
|---|---|---|---|
| Equations | 82 | 51 | 49 |
| Area and Volume | 67 | 53 | 35 |
| Fractions, Decimals and Percent | 90 | 64 | 52 |
| Factoring | 39 | 55 | 38 |
| Geometric Figures | 37 | 47 | 39 |
| Exponents | 47 | 58 | 41 |
| Graphs | 58 | 70 | 56 |
| Estimation | 62 | 64 | 44 |
| Word Problems | 61 | 28 | 31 |
| Congruent and Similar Figures | 29 | 32 | 22 |

## Student Achievement

Mean scores by domains are reported in Table 22. Since the test instruments were not built to equal levels of difficulty by domain, either within or across grade levels, comparisons should not be made among these categories. However, to provide a further dimension to the meaning of these results, ratings of Interpretation Panels have been included for each domain.

Based on the Interpretation Panels' ratings of these results, students at the Grade 4 level did well on Algebraic Topics but less than satisfactorily on Problem Solving and somewhat less than expected on Measurement. At the Grade 7 level students performed at a lower than expected level on Measurement and Geometry. Grade 10 students demonstrated less than satisfactory performance on three of the five domains. They were Number and Operation, Geometry and Algebraic Topics.

**Table 22**
**Mean Scores and Ratings by Achievement Domain**
**(percent)**

| Domain | Grade 4 Mean | Grade 4 Rating* | Grade 7 Mean | Grade 7 Rating* | Grade 10 Mean | Grade 10 Rating* |
|---|---|---|---|---|---|---|
| Number and Operation | 67 | S | 63 | S | 58 | M |
| Geometry | 64 | S | 53 | M-S | 47 | M |
| Measurement | 62 | M-S | 54 | M | 55 | S |
| Algebraic Topics | 67 | S-VS | 52 | S | 52 | M-S |
| Problem Solving | 47 | M | 52 | S | 42 | S |

* Panel Ratings were based on expected performance levels. The following scale was used: ST = Strength, VS = Very Satisfactory, S = Satisfactory, M = Marginal, W = Weak.

## CHAPTER 6
## TEACHERS' AND STUDENTS' OPINIONS OF MATHEMATICS

The overall ratings for importance, difficulty and enjoyment of mathematics by students and teachers of Grade 4 are shown in Figure 5. The numbers shown represent the mean percentage of positive responses given for each rating to the 10 major topics.

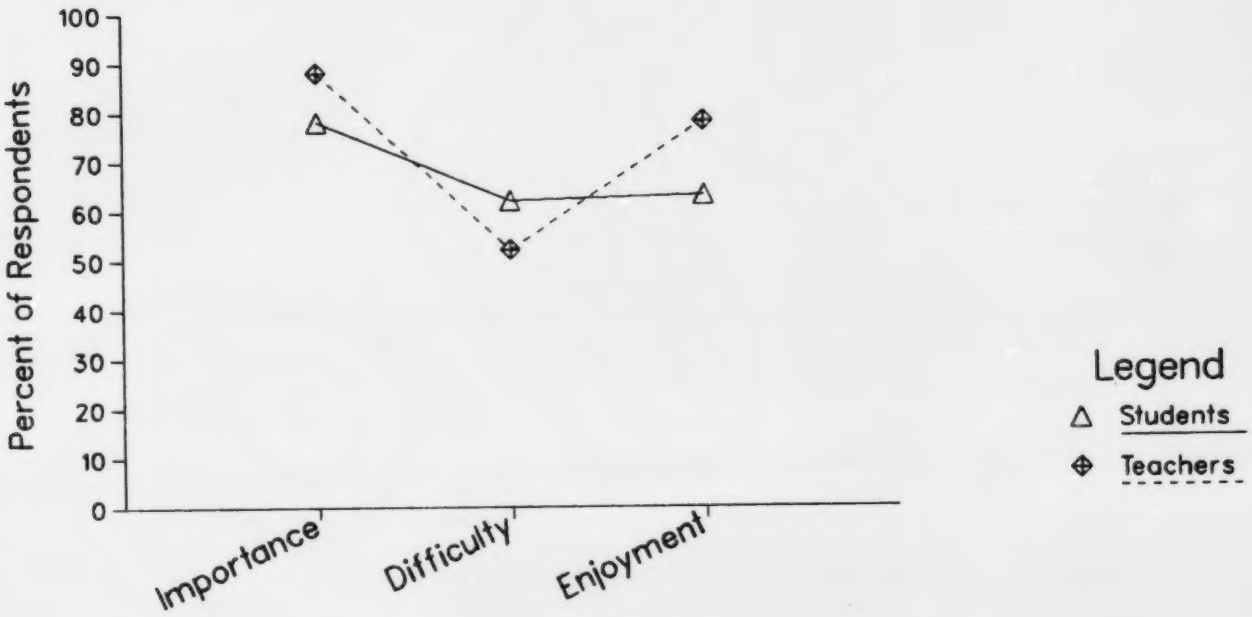


Figure 5. Students' and Teachers' opinions about mathematics--Grade 4.

Grade 4 teachers' opinions of mathematics as a subject ranged from a high of 88 percent who rated it important to only 52 percent who rated it easy to teach. Students' perceptions, on the other hand, reflected a narrower range. Their ratings ranged from a high of 78 percent for importance to a low of 62 percent who consider the subject easy to learn. While teachers' opinions of importance and enjoyment were higher than those of their students, teachers apparently consider mathematics more difficult to teach than students do to learn.

Students' and teachers' ratings at Grade 7 are shown in Figure 6. As was the case at Grade 4, these results represent the average proportion of respondents who gave a positive rating to the 10 major subject areas.

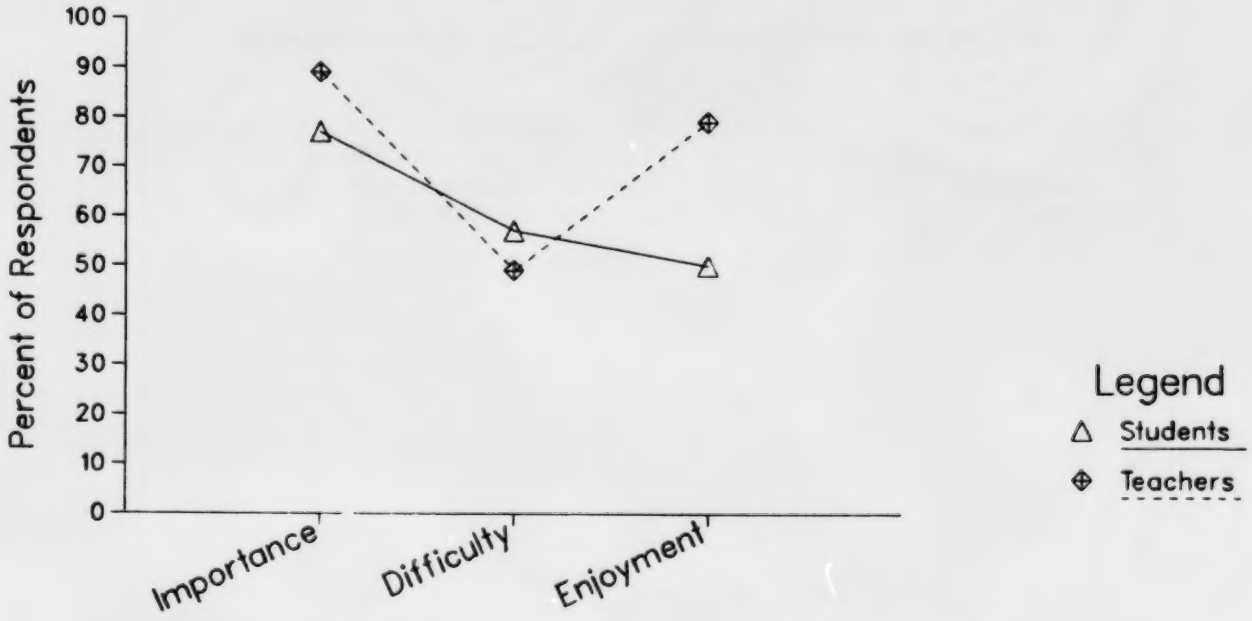


Figure 6. Students' and Teachers' opinions about mathematics--Grade 7.

Figure 6 shows a pattern of student and teacher ratings similar to the one at Grade 4. Student ratings at this level on difficulty and enjoyment, however, were considerably lower than those at Grade 4. For example, 57 percent found the subject easy while only 50 percent enjoyed it.

Only 49 percent of Grade 7 teachers found the subject easy to teach while 57 percent of their students found it easy to learn. This was similar to results from Grade 4.

Grade 10 teachers' opinions, shown in Figure 7, (although somewhat lower), showed a similar pattern to those of teachers at Grades 4 and 7. Students at this grade level ranked importance first, difficulty second, and enjoyment third. However, they were less enthusiastic than students at the other grade levels with ratings for three categories of only 57, 52 and 41 percent respectively.

Comparisons across grade levels between the perceptions of teachers and students revealed a similar trend. At all grade levels teachers' ratings of importance and enjoyment were higher than those of their students. However, teachers at all three grade levels found mathematics more difficult to teach than their students found it to learn.

Figure 7. Students' and Teachers' opinions about mathematics--Grade 10.

### Effects of Teachers' Opinions on Those of Their Students

In order to determine the extent to which teachers' opinions might have affected those of their students, or vice versa, it was necessary to include time as a variable. This made it possible to examine the strengths of relationships between teachers' and students' opinions at the beginning of a course and also at the end of it. Since the 1985 Assessment was administered only near the end of the school year, no information on the relationships between these opinions was available at the beginning of the school year. Consequently, it was necessary to go beyond the 1985 study to answer this question.

As indicated in Chapter 1, a large urban school district in British Columbia replicated the 1985 Assessment at the Grade 7 level during the 1986-86 school year using both a pre-test and a post-test. Results from that study made it possible to address the question on the direction of effects between students' and teachers' opinions of mathematics by using a cross-lagged panel correlation (Campbell and Stanley, 1963). Using this procedure the strengths of relationships between

the opinions of teachers on the importance of mathematics at Time 1 and those of students at Time 2 were compared with those of teachers at Time 2 and students at Time 1. The correlation found between the first two variables was 0.16 whereas between the latter two it was 0.10. These results indicate that teachers' opinions of the importance of mathematics have a greater effect on those of their students than the reverse. Teachers should therefore be cognizant of the effect their opinions of mathematics likely have on those of their students.

# CHAPTER 7
# RELATIONSHIPS BETWEEN INPUTS AND OUTPUTS

Results based on further analysis of the data are reported in this chapter. Included among the findings are the strengths of relationships among variables, the factors into which variables clustered, and the determination of the amount of variance in student achievement explained by these factors. In order to determine these relationships it was necessary to link teachers' responses to the Teacher Questionnaire with results from their classes. This was done by matching teacher and student files by common class code numbers.

To gain a measure of the strengths of relationships, correlation coefficients were calculated between pairs of variables within input categories listed in Table 23, and between these variables and student achievement. Variables were then clustered into groups which shared a common underlying dimension through the use of factor analysis. Purposes of this procedure were to examine the composition of these clusters and to prepare the data for further analysis. At the final stage of analysis, multiple regression techniques were applied. The factors from each input category were regressed on the achievement variable and the amount of explained variance determined. The output measure in these analyses was achievement on test total. It consisted of the mean for each class on all achievement items contained in the curricular domains.

In order to determine values for responses to questions, all options were coded numerically on interval scales. The weighting assigned to each option is reported in Appendix A. Relationships between variables were then calculated and reported as correlation coefficients.

## Relationships among Student Background Variables

As is shown in Table 23, relationships between language first spoken and language currently spoken in the home were strong at each grade level. The correlation coefficients for these relationships were 0.84, 0.81 and 0.79, respectively. These results are not surprising since, for a large majority of students, English was their first language.

Strong relationships were found between parents' educational levels at Grades 4 and 7: the correlation coefficients were 0.71 and 0.66, respectively. At the Grade 10 level, however, the strength of this relationship was considerably lower with a correlation of 0.36.

**Table 23**
**Correlations among Selected Student Background Variables and Achievement**

| Variable | Grade Level 4 | 7 | 10 |
|---|---|---|---|
| Language first and currently spoken | 0.84 | 0.81 | 0.79 |
| Educational levels of mother and father | 0.71 | 0.66 | 0.36 |
| Achievement and mothers' education | 0.34 | 0.21 | 0.76 |
| Achievement and fathers' education | 0.32 | 0.27 | 0.39 |
| Achievement and time on homework | -0.12 | 0.05 | 0.27 |

Note. All correlations reported in this table are significant at the 0.05 level.

Significant correlations were found between parents' educational levels and student achievement. The magnitude of the correlation, however, was greater at Grades 4 and 10 than at Grade 7. More specifically, the correlation of 0.76 between mothers' education and student achievement in Grade 10 was surprisingly high. Since parents' educational levels are measures frequently used as surrogates for socio-economic status, these results show that this characteristic correlates positively with achievement. This result confirms the importance of taking this variable into account when achievement results are interpreted.

Several interesting relationships were found between time spent on homework and achievement at different grade levels. At Grade 4, the correlation was negative, and this suggests that since little homework is assigned at this level, students experiencing difficulty likely receive more homework than others or else take longer to complete common assignments. At the Grade 7 level the correlation was positive but its magnitude was not large enough to draw any conclusions. At the Grade 10 level, however, the correlation was 0.27. This result provides some evidence to suggest that students in Grade 10 who spend more time on homework may achieve at a higher level than those who spend less. Teachers at Grade 10 should take this finding into account when assigning homework and when planning follow-up activities in the classroom related to this activity.

## Relationships among Teacher Background Variables

Teacher background variables which were examined included experience, inservice involvement, proportion of teaching load, preference to teach mathematics and professional preparation. Correlations of interest are reported in Table 24.

**Table 24**
**Correlations among Teacher Background Variables and Student Achievement**

| Variable | Grade Level 4 | 7 | 10 |
|---|---|---|---|
| Experience and preference to teach | 0.15* | 0.27* | 0.47* |
| Attendance at conf. and workshops | 0.33* | 0.32* | 0.35* |
| Math courses and math ed. courses | 0.36* | 0.41* | 0.55* |
| Achievement and experience | 0.05 | 0.05 | 0.26* |
| Achievement and math conferences | 0.05 | 0.04 | 0.20* |
| Achievement and workshops | 0.09* | 0.12* | 0.18* |
| Achievement and math courses | -0.04 | 0.05 | 0.19* |
| Achievement and math ed. courses | 0.02 | 0.09* | 0.15* |
| Achievement and proportion of load | -0.04 | -0.07* | 0.32* |

*correlations significant at the 0.05 level.

Moderate but significant correlations among teacher background variables were found between attendance at mathematics conferences and mathematics workshops, and between the number of post-secondary mathematics courses completed and the number of mathematics methods courses completed. These correlations, which ranged from 0.32 to 0.55, were similar for teachers at each of the grade levels. It was notable, however, that the relationship between the number of years of experience and preference to teach mathematics was considerably stronger for teachers of Grade 10 than for either of the other two grade levels. For instance, the correlation between these variables was 0.47 for Grade 10 teachers compared to 0.27 for those at Grade 7 and 0.15 for teachers at Grade 4. This difference is likely because most teachers of

mathematics at Grade 10 are mathematics specialists, and this is not usually the case at the other grade levels.

Relationships between teacher background variables and student achievement were markedly different at Grade 10 than at the other grade levels. Although most Grade 10 teachers were mathematics specialists, some with a different area of specialty may have been assigned a mathematics class due to cutbacks in staff and shifts in enrollment patterns. Results from these re-assigned teachers likely provided for some variance in background results and in achievement levels. The combination of specialist and non-specialist teachers of mathematics likely had an upward effect on the magnitudes of correlation coefficients. For example, an examination of the correlations between achievement and teacher background variables shown in Table 24 reveals a different pattern at each grade level.

The only significant relationship between teacher background and student achievement at the Grade 4 level was with the number of mathematics workshops attended during the previous three years. However, with a correlation coefficient of 0.09 this relationship was rather weak. Based on these results little or no evidence was found at the Grade 4 level which related teacher background to student achievement.

At the Grade 7 level three of the six teacher background variables were significantly related to achievement. They were the number of workshops attended during the previous three years, the number of mathematics education courses completed, and the proportion of teaching load given to mathematics. The correlation between achievement and the last background variable, however, was negative.

All six of the teacher background variables at the Grade 10 level were significantly related to student achievement. The magnitudes of the correlation coefficients, which ranged from 0.15 to 0.32, were greater than at either of the other two grade levels. This result provides evidence to suggest that higher levels of achievement are associated with teachers who specialize in teaching mathematics at the Grade 10 level. The correlations also provide some evidence to support the contention that achievement in mathematics at the Grade 10 level is associated with such teacher variables as years of experience, involvement in professional development activities and the extent of professional preparation.

### Relationships among Classroom Organization Variables

Teachers were asked a number of questions related to the structure of their classes and the amount of time spent on different types of activities. Included among the questions were the type of class, the frequency and duration of its meetings, and the proportion of class time spent on activities

such as testing, homework follow-up, individual seatwork, introduction of new topics and computational drill. An additional question dealt with the number of students called upon to answer questions in the most recent period. The correlations among these variables and between them and student achievement are shown in Table 25.

**Table 25**
**Correlations among Classroom Organization Variables and Achievement**

| Variables | Grade Level 4 | 7 | 10 |
|---|---|---|---|
| Type of program and computation | -0.14* | 0.01 | -0.19* |
| Type of program and homework | -0.03 | -0.07* | 0.20* |
| Frequency of testing and computation | 0.08* | 0.16* | 0.10* |
| Number and duration of classes | -0.23* | -0.39* | 0.06 |
| Homework activities and students questioned | 0.09* | 0.17* | 0.22* |
| Homework activities and indiv. seatwork | 0.00 | -0.11* | -0.20* |
| Indiv. seatwork and students questioned | -0.07* | -0.02 | -0.23* |
| Indiv. seatwork and new topics | -0.27* | -0.26* | -0.37* |
| Achievement and type of program | 0.23* | 0.19* | 0.73* |
| Achievement and total time | 0.05 | 0.08* | -0.07* |
| Achievement and computation | -0.04 | -0.03 | -0.19* |

*significant at the 0.05 level

Several interesting relationships were found between the structure of classes and the amounts of time spent on different activities. For example, correlations between type of program and time spent on computational drill were -0.14 and -0.19 at Grades 4 and 10 respectively. These correlations indicate, not surprisingly, that more time is spent on computational drill with modified classes than with enriched ones at these grade levels. No significant correlation, however, was found between these variables at the Grade 7 level.

Significant relationships were also found between the type of program and amount of time spent on homework-related activities at Grades 7 and 10. At the Grade 7 level the correlation was negative, contrary to the result at Grade 10. These results may indicate that more time is spent on discussion of homework with students in modified classes at the Grade 7 level, while more time is spent on this activity with regular or enriched classes at Grade 10. The negative correlations of -0.23 and -0.39 between the frequency and duration of classes at Grades 4 and 7 respectively, simply indicate that as the number of classes per week increases their duration decreases.

A number of strong relationships were found among proportions of class time spent on various activities. For instance, correlations between frequency of testing and time spent on computational drill were significant at each of the grade levels. This result may indicate that teachers tend to test computation frequently when drill in this area is emphasized. Negative correlations were found between time spent on individual seat work and several other activities at most grade levels. Negative relationships with this variable were found with time spent on homework-related activities, number of students questioned, and the introduction of new topics.

Relationships between type of program and achievement were significant at each grade level. The correlations between these variables were 0.23, 0.19, and 0.73 at Grades 4, 7 and 10, respectively. The reason for such a strong correlation at the Grade 10 level was likely due to streaming in secondary schools. This practice is less common in elementary schools.

Negative correlations were found between achievement and time spent on computational drill. This relationship was not significant at Grades 4 and 7, but the correlation of -0.19 at Grade 10 was. This may indicate that more time is spent on computational drill in classes which tend to achieve at a low level than those where achievement is high.

### Relationships among Problem-Solving Process Variables

Scale S on the Teacher Questionnaire contained a series of questions which dealt with the teaching of problem solving. Included in the scale were questions on teacher attitude toward the teaching of problem solving, in-service involvement, and the number of different approaches and sources of materials used to teach the topic. Relationships of interest among these variables and between these variables and achievement are reported in Table 26. All but one were statistically significant.

Table 26
Correlations among Problem-Solving Processes and Achievement

| Variable | Grade Level 4 | 7 | 10 |
|---|---|---|---|
| Expectations of student enjoyment and achievement | 0.47 | 0.52 | 0.47 |
| Satisfaction and ease in teaching prob. solv. | 0.34 | 0.24 | 0.24 |
| Number of strategies and sources of exercises | 0.46 | 0.40 | 0.55 |
| Number of strategies and motivational activities | 0.42 | 0.34 | 0.45 |
| Number of strategies and problem-types assigned | 0.48 | 0.43 | 0.44 |
| Sources of exercises and motivational activities | 0.62 | 0.52 | 0.64 |
| Sources of exercises and problem-types assigned | 0.49 | 0.40 | 0.46 |
| Sources of exercises and classroom features | 0.49 | 0.40 | 0.40 |
| Motivational activities and problem-types assigned | 0.51 | 0.37 | 0.47 |
| Motivational activities and classroom features | 0.66 | 0.46 | 0.63 |
| Problem-types assigned and classroom features | 0.48 | 0.37 | 0.36 |
| Achievement and number of strategies | 0.09 | 0.08 | 0.15 |
| Achievement and sources of exercises | 0.06 | 0.11 | 0.22 |
| Achievement and motivational activities | $0.05^{ns}$ | 0.10 | 0.20 |
| Achievement and problem-types assigned | 0.11 | 0.08 | 0.20 |
| Achievement and expectations of student enjoyment | 0.17 | 0.19 | 0.28 |
| Achievement and expectations of student achievement | 0.28 | 0.30 | 0.42 |

$^{ns}$not significant at the 0.05 level

The relationships found between teachers' expectations of student enjoyment and their expectations of student achievement, and the satisfaction and enjoyment they experienced in teaching the topic were found to be positive and significant at each grade level. Correlations between the first pair of variables were relatively strong at each of Grades 4, 7, and 10 with correlation coefficients of 0.47,

0.52 and 0.47, respectively. More moderate but still significant relationships were found between teachers' ratings of the satisfaction they experienced in teaching problem solving and how easy they found it to teach. The strengths among all of these relationships, and the commonalty of results across grade levels, may indicate a common construct underlying the variables. It may be that they are all measures of attitude toward the teaching of problem solving.

All of the relationships between the numbers of different approaches and sources of materials used in the teaching of problem solving reported in Table 25 were statistically significant. Correlation coefficients between these variables ranged from 0.34 to 0.66, with 23 out of the 27 relationships at 0.40 or higher. Among the strongest of these relationships were the number of different sources of exercises and the number of motivational activities used, and the number of motivational activities and different classroom features used such as bulletin boards and problem of the week. These results indicate that teachers who use different approaches likely also employ different sources of materials. These variables may be measures of teachers' levels of flexibility in the teaching of problem solving.

Although the magnitudes of the correlations between problem-solving process variables and achievement were found to be lower than they were among themselves, all but one correlation with achievement was statistically significant. The strongest correlations across grade levels were between teachers' expectations of student enjoyment and achievement, and students' actual achievement. For example, correlations between expectations of student enjoyment and their actual achievement ranged from 0.17 to 0.28. Correlations between teacher expectations of student achievement and their actual results were somewhat higher with a range between 0.28 and 0.42.

Correlations between achievement and measures of teacher flexibility were higher at Grade 10 than at either of the other two grade levels. For example, relationships between achievement and several other variables from this category were as follows: number of strategies taught, number of different sources of exercises, number of different motivational activities used, and number of different problem types assigned.

### Relationships among Teachers' Opinions of Mathematics

The strengths of relationships were also determined among teachers' scores on each of three opinion scales and between these scores and students' achievement in mathematics. The scales were measures of teachers' opinions of the importance of mathematics, the difficulty experienced in teaching it, and

the enjoyment found in teaching it. Results are reported in Table 27.

**Table 27**
**Correlations among Teachers' Opinions of Mathematics**

| Variable | Grade Level 4 | 7 | 10 |
|---|---|---|---|
| Importance and difficulty | 0.43 | 0.20 | 0.53 |
| Importance and enjoyment | 0.63 | 0.58 | 0.69 |
| Difficulty and enjoyment | 0.49 | 0.37 | 0.57 |
| Achievement and importance | 0.09 | 0.10 | 0.38 |
| Achievement and difficulty | 0.17 | 0.16 | 0.42 |
| Achievement and enjoyment | $0.03^{ns}$ | $0.05^{ns}$ | 0.28 |

$^{ns}$not significant at the 0.05 level

All of the relationships among the teacher opinion variables were significant. The strongest of these were between the importance of mathematics and the enjoyment experienced in teaching it. Correlations between these variables were 0.63 for teachers of Grade 4, 0.58 for teachers of Grade 7, and 0.69 for those at the Grade 10 level. The strength of all these relationships indicates that teachers share common opinions of different aspects of mathematics as a subject.

Correlations between teachers' opinions and students' achievement were significantly related in 7 out of 9 cases. The strongest relationships were between opinions of difficulty to teach and achievement. Correlations between these variables were 0.17, 0.16 and 0.42 at Grades 4, 7 and 10, respectively. Relationships were markedly stronger at Grade 10 than at either of the other two grade levels. For example, correlations between achievement and the three scales ranged between 0.28 and 0.42 at this grade level. These results indicate that, for the most part, achievement and teacher opinions of mathematics are positively related.

## Relationships among Students' Opinions of Mathematics

The three opinion scales for students dealt with the importance of mathematics, difficulty in learning mathematics, and enjoyment in learning mathematics. The strengths of the relationships among these variables and between them and achievement are shown in Table 28.

**Table 28**
**Correlations among Students' Opinions of Mathematics**

| Variable | Grade Level 4 | 7 | 10 |
|---|---|---|---|
| Importance and difficulty | 0.66 | 0.57 | 0.64 |
| Importance and enjoyment | 0.67 | 0.53 | 0.61 |
| Difficulty and enjoyment | 0.70 | 0.59 | 0.60 |
| Achievement and importance | 0.17 | 0.14 | 0.42 |
| Achievement and difficulty | 0.17 | 0.15 | 0.45 |
| Achievement and enjoyment | 0.09 | 0.27 | 0.27 |

Note. All relationships are significant at the 0.05 level.

Results indicate that relationships among students' opinions of mathematics were stronger than those of their teachers. For example, correlations among these opinions by students at all grade levels ranged from 0.53 to 0.70. At the Grade 4 level they were strongest, ranging from 0.66 to 0.70. These findings suggest that a common construct underlies all of the opinions.

Correlations between students' achievement and their opinions were of lower magnitudes than those involving their opinions. However, all were statistically significant with relationships between these variables being strongest at Grade 10. The correlations between achievement and opinions at this level were 0.42 for importance, 0.45 for difficulty and 0.27 for enjoyment. These results establish an important relationship between student opinions of mathematics and achievement. This finding underscores the importance of the affective domain as a major outcome of the curriculum. It is essential that teachers and curriculum developers become aware of the strength of this relationship.

## Factor Analysis

A factor analysis was undertaken to identify groups of variables within each of the input categories which possessed common underlying constructs and to prepare the data for further analysis. Students' and teachers' opinions were not factored since they had already been reduced to three variables each by summing the scales.

The number of factors obtained for each input category is shown in Table 29. The number of variables contained in Table 29. The number of variables contained in the input categories was reduced from 39 to 11 at Grades 4 and 10, and to 12 at Grade 7.

**Table 29**
**Factors For Each Input Category**

| Input Category | Number of Factors | | |
|---|---|---|---|
| | Grade 4 | Grade 7 | Grade 10 |
| Student Background | 2 | 2 | 2 |
| Teacher Background | 3 | 2 | 2 |
| Classroom Organization | 4 | 5 | 4 |
| Problem Solving Process | 2 | 3 | 3 |

Variables which clustered together at each of the grade levels are shown below. In some cases they may share a common construct or underlying dimension.

- Language first and currently spoken
- Educational leveling both parents
- Experience and preference to teach mathematics
- Conference and workshops attended
- Mathematics and mathematics education courses completed
- Time spent on seatwork and on introducing new topics
- Time spent on testing and on computational drill
- Time spent on homework activities and number of student questioned.
- Number of different strategies taught, sources of exercises, motivational activities and problem-types assigned.
- Teachers' expectations of student enjoyment of and achievement in problem solving.
- Teachers' satisfaction in teaching problem solving and case found in teaching their topic.

## Variances in Students' Achievement

At this stage of analysis multiple regression techniques were used to determine the amount of variance in achievement at each grade level which could be explained by factors in the input categories, and their relative effects on predicted levels of achievement. To address these issues all factors from across categories were regressed on the achievement variable at each grade level. Results showed the relative effect of all factors on achievement, taking into account any shared variances held in common by factors from different categories.

The variances in student achievement explained by factors from each input category are reported in Table 30. Results are reported as percentages.

**Table 30**
**Variances in Student Achievement**

| Grade Level | Percent of Variance Explained |
|---|---|
| 4 | 17 |
| 7 | 28 |
| 10 | 60 |

The inputs accounted for substantially more of the variance in achievement at Grade 10 than at either of the other two grade levels. Sixty percent of the variance in achievement was explained by inputs at this grade level, compared to 17 percent at Grade 4 and 28 percent at Grade 7. The greater proportion at Grade 10 may be due to a variety of reasons, probably including the use of mathematics specialists and streaming of classes at the secondary level.

## Relative Effects of Inputs on Achievement

In addition to examining the amount of variance in student achievement accounted for by inputs of the system, the relative effect of each major input category was also determined. To report these comparisons beta weights were calculated.

Beta weights are standardized regression coefficients, drawn from the regression model. A comparison of beta weights provides a measure of the relative effects that input

variables associated with each major category have on the achievement variable. The value of each beta weight indicates the number of standard deviation units of change that could be predicted in the achievement variable when the value of the input category changes by one standard deviation unit. Since the effects attributed to beta weights are additive, those weights associated with more than one factor within a category were summed.

The relative effects on student achievement in mathematics predicted by variables associated with each input category from the 1985 Provincial Assessment are shown in Figure 8. Values are standardized indices of relative effects on achievement.

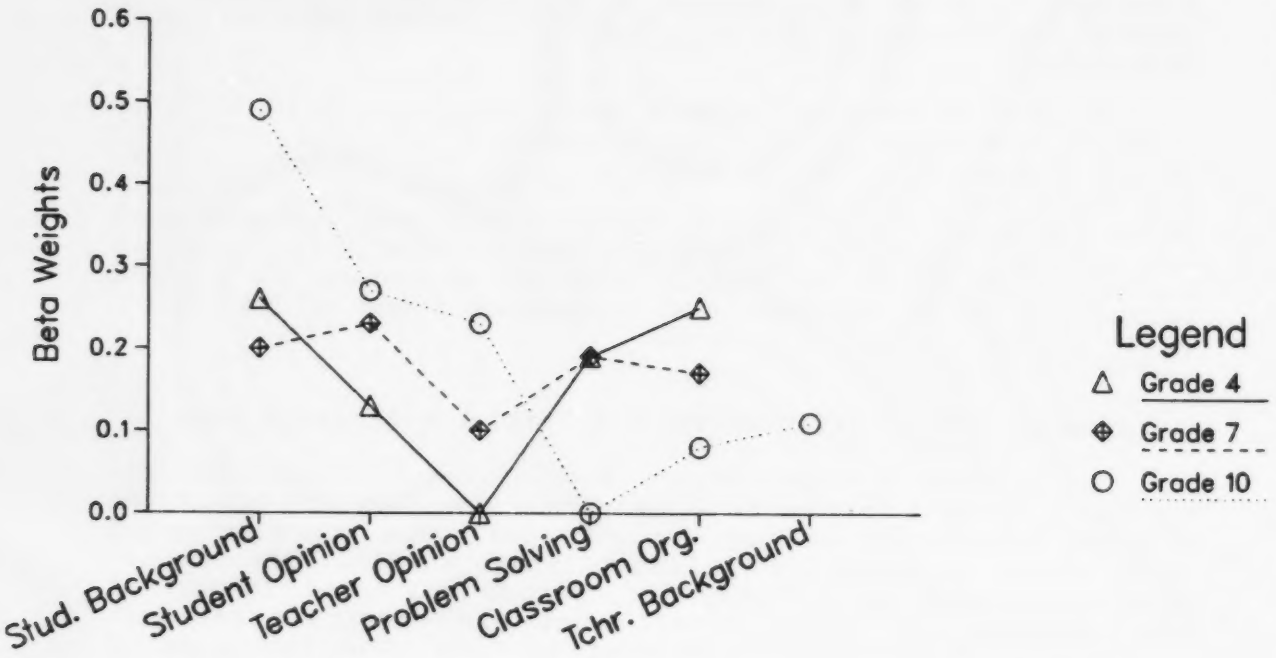


Figure 8. Effects of schooling on achievement in mathematics.

As shown in Figure 8, teacher background variables did not account for any measurable effect on student achievement in Grades 4 and 7. It did, however, have some effect at Grade 10. Teacher opinion variables had no effect at Grade 4, but

they predicted a limited change in achievement in Grade 7, and more than twice that amount in Grade 10.

At the Grade 4 level changes in student background and classroom organization, with beta weights of 0.26 and 0.25, respectively, predicted the greatest change in achievement. Problem-solving processes and student opinions, with beta weights of 0.19 and 0.13 respectively, had a more limited effect. Teachers' backgrounds and opinions, as mentioned earlier, had no measurable effect.

The greatest predicted effect on change in student achievement at the Grade 7 level corresponded to changes in student background and student opinion variables. Beta weights for these input categories were 0.20 and 0.23 respectively. Although no measurable effect was attributed to change in teacher background, the other input categories were assigned beta weights.

Student background, with a beta weight of 0.49 had the greatest potential effect on achievement at the Grade 10 level. Student and teacher opinions, with beta weights of 0.27 and 0.23, were the next highest weightings. At this grade level changes in students' backgrounds and opinions predicted the greatest change in achievement whereas change in classroom processes predicted the least. With the exception of student background, this contrasted with results found at the other grade levels.

### Comparisons of Relative Effects Using Longitudinal Data

In the 1987 replication study, results showing the relative effects of each major input category on predicted student achievement at the Grade 7 level were compared using both cross-sectional and longitudinal models. The cross-sectional model used survey information collected in May of 1987 whereas the longitudinal model also included pre-test information collected in September of 1986. The inclusion of the September data enabled control for entry level behavior of students. Results are shown in Figure 9.

Based on the information shown in Figure 9, student opinion and background variables show considerably stronger effects when student entry level behaviors were not controlled than when they were. When these behaviors were not controlled, the beta weight for student background was 0.26 compared to 0.16 when they were. Students' opinions, on the other hand, had beta weights of 0.42 without the control and 0.27 with it.

The differences for student background variables was expected since they are not likely to change a great deal between the beginning of a school year and the end of it. Consequently results from the September test would have

accounted for a substantial portion of their effect on students' achievement. Similarly, part of the effect of student opinions of mathematics would also be accounted for by the September test. However, the beta weight of 0.27 for the students' opinions, based on the longitudinal results, suggests that student experiences in a given year can still have an effect on their opinions of mathematics. These results indicate that caution should be taken when interpreting survey data. Findings, based on student background and opinions of mathematics, should not be attributed solely to current classroom practices.

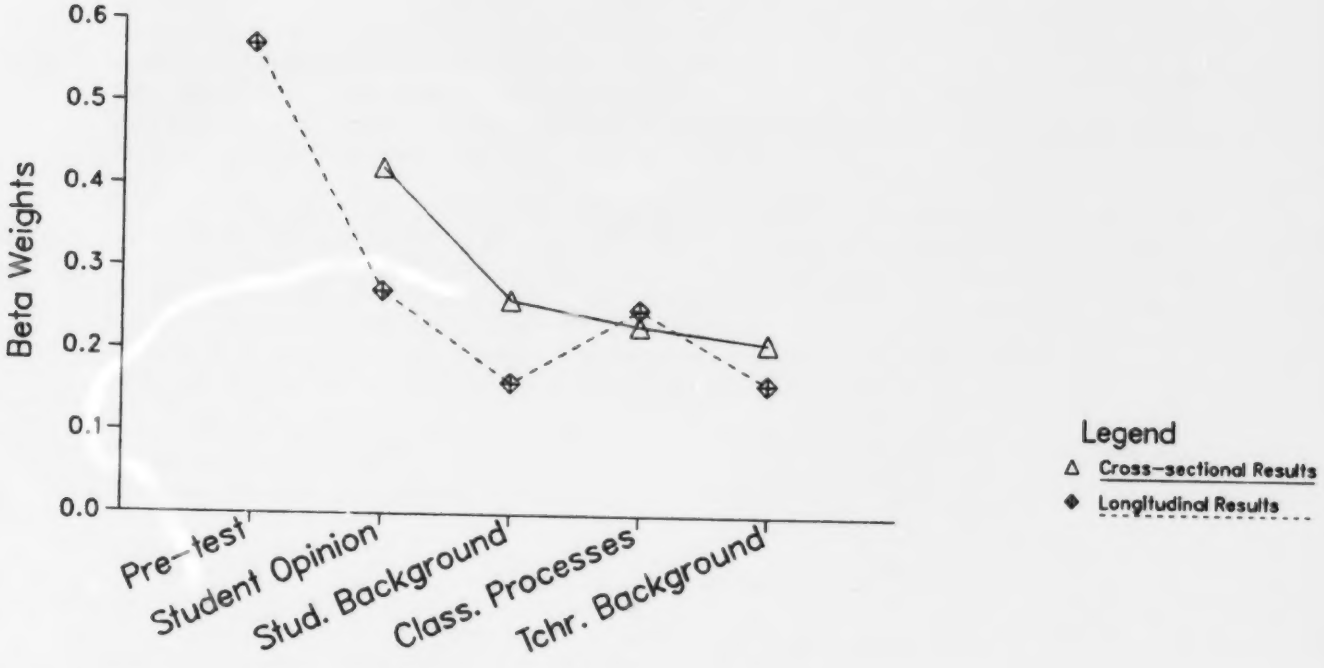


Figure 9. Effects of schooling on achievement : cross-sectional vs. longitudinal data.

The relative effects of classroom processes on achievement were found to be similar in both cases. The cross-sectional data yielded a beta weight of 0.23 compared to 0.25 for the longitudinal data in this category. Similar results with both sets of data were also found for the effects of teacher background. Based on these findings, similar conclusions related to these input categories could be expected either with or without pre-test information.

# CHAPTER 8
# SUMMARY AND RECOMMENDATIONS

Information gained from this study included a description of the background and behaviors of teachers and students in Grades 4, 7 and 10 in British Columbia schools. Some of the significant findings included the strengths of relationships between input variables such as students' and teachers' backgrounds, students' and teachers' opinions of mathematics, classroom organization and problem-solving processes, and outputs of the educational system as reflected in student achievement in mathematics. Other findings of interest provided comparisons between the relationships of these variables at three different levels of the system: Grades 4, 7 and 10. Further findings reported comparisons between opinions of mathematics held by students and their teachers. The relative effects of major input categories on predicted achievement scores were also reported.

Through the interpretation of these findings it is hoped that direction will be gained for course planning, approaches to the teaching of mathematics, organization of classrooms and planning for pre-service and in-service activities. Although causal relationships are not claimed, a number of background characteristics and teaching behaviors associated with student achievement in mathematics are identified.

Described below are the variables found to be associated with achievement, listed separately under each input category. On the basis of these findings a number of recommendations are made.

## Student Background

Mothers' and fathers' levels of education were found to be strongly related to student achievement at each grade level. These measures, which are often used an indicators of socio-economic status, confirm similar findings from other research studies. Time spent on homework correlated negatively with achievement at Grade 4, showed a low but positive correlation at Grade 7, and related strongly to achievement at Grade 10. These results could indicate that students who are low achievers may receive additional homework at the Grade 4 level or else take longer to complete common assignments and that students who perform well at the Grade 10 level spend more time on homework. Based on these results the following recommendations are made:

1. *In judging the effectiveness of a mathematics program, based on assessment results, socio-economic status should be taken into account as a factor which has an effect on achievement levels.*

2. *Teachers should review their current practices in assigning homework, and make differentiated assignments taking into account the ability levels of the students involved.*

### Teacher Background

The strengths of relationships between teacher background variables and student achievement were markedly different at each of the three grade levels. Associations between these variables and achievement ranged from weak at Grade 4 to strong at Grade 10. A list of the variables which were found to be associated with achievement at each grade level follows.

| | |
|---|---|
| Grade 4 | attendance at mathematics workshops |
| Grade 7 | attendance at mathematics workshops<br>number of mathematics methods courses<br>proportion of teaching load |
| Grade 10 | attendance at mathematics workshops<br>number of mathematics methods courses<br>proportion of teaching load<br>attendance at mathematics conferences<br>experience |

The number of teacher background variables found to be associated with student achievement and the strengths of those relationships increased at each successive grade level. Attendance at mathematics workshops was common at each level. At Grade 10 variables which related to professional preparation and experience provided a profile of teachers whose classes achieved well. This result implies that the re-deployment of non-specialist teachers to teach mathematics at the secondary level may have an adverse effect on student achievement.

On the basis of these results the following recommendation is made:

3. *Teachers of secondary mathematics should be trained in that subject area. The current practice of assigning non-specialist teachers to teach mathematics at this level should be reviewed.*

### Classroom Organization

Few relationships of significance were found between classroom organization variables and achievement. One variable with a strong association at all of the grade levels, however, was the type of program. This result was expected since it confirmed that the average class achievement level increased as results from modified, regular, and enriched classes were compared. This was particularly true at Grade 10.

### Problem-Solving Processes

Several variables in the problem-solving processes category were found to be associated with student achievement. The following list of variables was related to student achievement at all of the grade levels:

- number of different strategies taught
- number of different sources of exercises
- number of different activities for motivation
- number of different problem-types assigned
- teachers' expectations of student enjoyment
- teachers' expectations of student achievement

The first four variables listed above could be viewed as indicators of teacher flexibility whereas the latter two are clearly indicators of teachers' expectations. Based on these findings the following recommendations are made:

4. *Teacher flexibility should be encouraged through the provision of workshops on alternate approaches to the teaching of mathematics and through the development of resource books to supplement textbooks.*

5. *Teachers should hold reasonable but high expectations. This should be encouraged through articulation on procedures for standard setting.*

### Opinions of Mathematics

Students' opinions of the importance, difficulty and enjoyment they experienced with mathematics were strongly related to their achievement at each of the grade levels. Similar results were found with the relationships between opinions held by teachers and the performance of their classes. These findings confirm the importance of outcomes from the affective domain as integral components of the curriculum. As a result the following recommendation is made:

6. *Curriculum developers and teachers should be cognizant of the relationship between the affective domain and student achievement in the cognitive domain. This awareness should have some effect on curriculum design and on teachers' efforts to provide students with positive experiences in mathematics.*

## Survey and Longitudinal Results

An interesting finding, which came from the 1987 replication study, dealt with the appropriateness of using cross-sectional information for the purposes of drawing conclusions about the relationships between input variables and student outcomes. The results showed that after controlling entry level knowledge and behaviors of students, that classroom process variables had the same relative effect on expected performance as they did when large scale survey results without pre-tests were used. This finding validates the use of results from provincial assessments for such a purpose.

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# APPENDIX A

## Coding Of Variables

## Option Codes for Independent Variables

| Variable | Item Number | Number Codes by Option | | | | | |
|---|---|---|---|---|---|---|---|
| | | A | B | C | D | E | F |
| A. Student Background | | | | | | | |
| SB1 | 1 | 2 | 1 | 1 | | | |
| SB2 | 2 | 2 | 1 | 1 | | | |
| SB3 | 7 | 1 | 2 | 3 | 4 | 5 | |
| SB4 | 9 | 1 | 2 | 3 | 4 | - | |
| SB5 | 10 | 1 | 2 | 3 | 4 | - | |
| B. Teacher Background | | | | | | | |
| TB1 | 1 | 1 | 2 | 3 | 4 | 5 | |
| TB2 | 2 | 1 | 3 | 2 | | | |
| TB3 | 3 | 1 | 2 | 3 | 4 | 5 | |
| TB4 | 5 | 2 | 1 | | | | |
| TB5 | 6 | 2 | 1 | | | | |
| TB6 | 8 | 1 | 2 | 3 | 4 | 5 | |
| TB7 | 9 | 1 | 2 | 3 | 4 | 5 | |
| C. Student Perception | | | | | | | |
| SP1 | 1 | 1 | 2 | 3 | 4 | 5 | |
| SP2 | 2 | 1 | 2 | 3 | 4 | 5 | |
| SP3 | 3 | 1 | 2 | 3 | 4 | 5 | |
| SP4 | 4 | 1 | 2 | 3 | 4 | 5 | |
| SP5 | 5 | 1 | 2 | 3 | 4 | 5 | |
| SP6 | 6 | 1 | 2 | 3 | 4 | 5 | |
| SP7 | 7 | 1 | 2 | 3 | 4 | 5 | |
| SP8 | 8 | 1 | 2 | 3 | 4 | 5 | |
| SP9 | 9 | 1 | 2 | 3 | 4 | 5 | |
| SP10 | 10 | 1 | 2 | 3 | 4 | 5 | |
| D. Teacher Perception | | | | | | | |
| TP1 | 1 | 1 | 2 | 3 | 4 | 5 | |
| TP2 | 2 | 1 | 2 | 3 | 4 | 5 | |
| TP3 | 3 | 1 | 2 | 3 | 4 | 5 | |
| TP4 | 4 | 1 | 2 | 3 | 4 | 5 | |
| TP5 | 5 | 1 | 2 | 3 | 4 | 5 | |
| TP6 | 6 | 1 | 2 | 3 | 4 | 5 | |
| TP7 | 7 | 1 | 2 | 3 | 4 | 5 | |
| TP8 | 8 | 1 | 2 | 3 | 4 | 5 | |
| TP9 | 9 | 1 | 2 | 3 | 4 | 5 | |
| TP10 | 10 | 1 | 2 | 3 | 4 | 5 | |
| E. Classroom Organization | | | | | | | |
| CO1 | 10 | 2 | 1 | 3 | - | - | - |
| CO2 | 11 | 5 | 4 | 3 | 2 | 1 | |
| CO3 | 12 | 3 | 4 | 5 | 6 | 7 | |
| CO4 | 13 | 15 | 38 | 53 | 68 | 83 | |
| CO5 | 14 | 1 | 2 | 3 | 4 | 5 | 6 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| CO6 | 15 | 1 | 2 | 3 | 4 | 5 | 6 |
| CO7 | 16 | 1 | 2 | 3 | 4 | 5 | 6 |
| CO8 | 17 | 1 | 2 | 3 | 4 | 5 | 6 |
| CO9 | 18 | 1 | 2 | 3 | 4 | 5 | 6 |
| CO10 | 19 | 1 | 2 | 3 | 4 | 5 | 6 |
| CO11 | 20 | 1 | 2 | 3 | 4 | 5 | 6 |

G. Problem Solving Processes

| | | | | | | |
|---|---|---|---|---|---|---|
| PS1 | 1 | 1 | 2 | 3 | 4 | 5 |
| PS2 | 2 | 1 | 2 | 3 | 4 | 5 |
| PS3 | 5 | 1 | 2 | 3 | 4 | 5 |
| PS4 | 7 | 1 | 2 | 3 | 4 | 5 |
| *PS5 | 8 | 1,0 | 1,0 | 1,0 | 1,0 | 1,0 |
| PS6 | 9 | 1 | 2 | 3 | 4 | 5 |
| *PS7 | 10 | 1,0 | 1,0 | 1,0 | 1,0 | 1,0 |
| *PS8 | 11 | 1,0 | 1,0 | 1,0 | 1,0 | 1,0 |
| PS9 | 12 | 1 | 5 | 3 | 2 | 4 |
| *PS10 | 14 | 1,0 | 1,0 | 1,0 | 1,0 | 1,0 |
| *PS11 | 15 | 1,0 | 1,0 | 1,0 | 1,0 | 1,0 |

* Multiple response items

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